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Published in:
Energy Policy

DOI:
10.1016/j.enpol.2016.08.007

Energy Policy 98 (2016) 12–18

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The importance of instrumental, symbolic, and environmental attributes for the adoption of smart energy systems

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HIGHLIGHTS

- What drives consumer adoption of a sustainable innovation?
- Evaluation of its symbolic attributes explained adoption of smart energy systems.
- Evaluations of its instrumental and environmental attributes did not explain adoption.
- Policy could stress and enhance symbolic attributes of smart energy systems.

ARTICLE INFO

Article history:
Received 24 April 2015
Received in revised form
6 August 2016
Accepted 8 August 2016
Available online 18 August 2016

Keywords:
Adoption of innovations
Symbolic attributes
Smart energy systems

ABSTRACT

The conceptual model on motivations to adopt sustainable innovations (Noppers et al., 2014) proved to be successful in explaining proxies of the adoption of sustainable innovations: positive evaluations of the utility (instrumental attributes), environmental impact (environmental attributes), and specifically the extent to which the innovation says something about a person (symbolic attributes) increased interest in and intention to adopt sustainable innovations. In this paper, we examined to what extent the evaluations of these three attributes can also explain the *actual* adoption of smart energy systems that facilitate sustainable energy use. Results showed that adopters of smart energy systems (who agreed to participate in a project in which these systems were tested) evaluated the symbolic attributes of these systems more positively than non-adopters (who did not participate in this project), while both groups did not differ in their evaluation of the instrumental and environmental attributes of smart energy systems. A logistic regression analysis indicated that only evaluations of the symbolic attributes explained actual adoption of smart energy systems. Policy could stress and enhance the symbolic attributes of sustainable innovations to encourage adoption.

1. Introduction

1.1. Introduction

The adoption of innovative products and services that use less energy or optimize the use of renewable energy sources is an important strategy for combatting climate change. Some promising sustainable innovations that were recently introduced to the market include electric cars, solar panels, and smart energy systems. This paper focuses on smart energy systems, which we define as devices that monitor the production and use of energy by households, and deliver households detailed feedback on their energy production and use. Such smart energy systems could reduce consumers' fossil energy use and related emissions of greenhouse gases, by increasing their understanding of ways to reduce their fossil energy use and to make better use of self-generated renewable energy sources. Matching the demand of energy to the available supply of renewable energy is important for the development of efficient and sustainable smart grids (Steg et al., 2015). Yet, the impact of smart energy systems on the quality of the environment depends in the first instance on whether consumers actually adopt these smart energy systems. Hence, it is vital to understand what drives consumers to adopt sustainable innovations such as smart energy systems (Sintov and Schultz, 2015).

Previous research revealed that several factors encourage or inhibit willingness to adopt sustainable innovations, including financial costs (Bockarjova and Steg, 2014; Sierzchula et al., 2014), environmental consequences (Bockarjova and

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http://dx.doi.org/10.1016/j.enpol.2016.08.007

Steg, 2014), technical support provided (Jager, 2006), and the extent to which consumers tend to be earlier or later adopters of the relevant product category (Noppers et al., 2015; cf. Rogers, 1962). Also, social factors influence the likelihood of adopting sustainable innovations, including social norms (Ozaki and Sevastyanova, 2011) or whether neighbors already adopted the innovation (Graziano and Gillingham, 2014). These studies typically focused on factors that affect the utility of sustainable innovations, and the expectations and behavior of significant others. Furthermore, some studies suggest that identity and self-expression considerations play a role in adopting sustainable innovations. For instance, studies on hybrid electric car ownership found that owners feel they can express themselves with a hybrid car (Heffner, 2007; Ozaki and Sevastyanova, 2011). On the basis of these findings and theorizing in consumer research, the conceptual model on motivations to adopt sustainable innovations was proposed (Noppers et al., 2014). According to this model, the likelihood of adopting a sustainable innovation depends on how consumers evaluate its instrumental, environmental and symbolic attributes. We will explain the model in the next Section.

1.2. The conceptual model on motivations to adopt sustainable innovations

The conceptual model on motivations to adopt sustainable innovations (Noppers et al., 2014, see Fig. 1) postulates that products afford several functions for consumers, which influence the likelihood of adoption (cf., Dittmar, 1992). First, instrumental attributes reflect the utility of owning and using a sustainable innovation (Dittmar, 1992; Noppers et al., 2014; Schuitema et al., 2013). For instance, electric cars have a limited range, and solar panels on one's roof do not produce energy all the time, which may inhibit their adoption. Smart energy systems monitor energy production and use and provide feedback on energy production and use, which can help the user to save money that may increase adoption likelihood. Second, the conceptual model suggests that a product may be adopted for its favorable environmental attributes (Noppers et al., 2014). Environmental attributes of sustainable innovations reflect the outcomes of owning and using a sustainable innovation for the quality of the environment (Noppers et al., 2014; 2015; Schuitema and De Groot, 2015; Sonnenberg et al., 2014). The environmental attributes of sustainable innovations often stand out as sustainable innovations are typically developed to help reduce environmental problems. The conceptual model suggest that next to the evaluations of the instrumental and environmental attributes, the evaluations symbolic attributes play an important role in the adoption likelihood of sustainable innovations. Symbolic attributes of sustainable innovations reflect the effects of owning and using sustainable innovations on one's (self-)identity and social status (Dittmar, 1992; Noppers et al., 2014; Schuitema et al., 2013). Indeed, previous research found that when people's status motives were activated, sustainable products were preferred over more luxurious non-sustainable products (Griskevicius et al., 2010), suggesting that perceptions of what a sustainable product says about the owner can increase preference for that product. Adopting a sustainable innovation can signal who or what we are or want to be (e.g., Heffner, 2007; Ozaki and Sevastyanova, 2011), both to ourselves and others, which can affect adoption likelihood.

Previous research on sustainable innovations revealed that evaluations of all three types of attributes predict unique variance in the likelihood of adoption of sustainable innovations. More specifically, more favorable evaluations of instrumental attributes, environmental attributes, and symbolic attributes increase adoption likelihood, as reflected in for example the acceptability of,

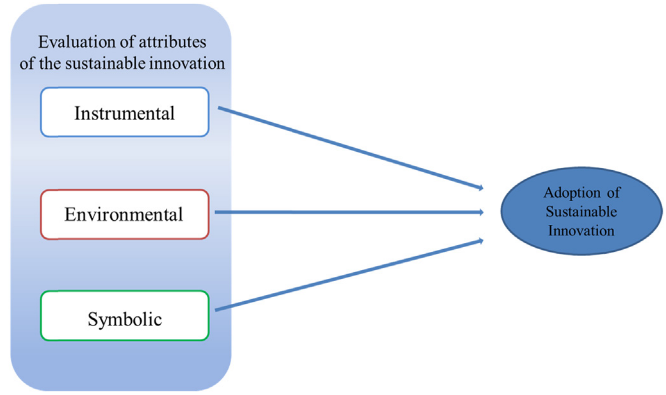

Fig. 1. The conceptual model on motivations to adopt sustainable innovations.

interest in and intention to adopt sustainable innovations (Korcaj et al., 2015; Noppers et al., 2014, 2015; Schuitema et al., 2013). Interestingly, the symbolic attributes appeared to be a relatively strong predictor of these proxies of adoption, and the symbolic attributes of sustainable innovations appeared to be evaluated more positively by earlier adopters as compared to later adopters (Noppers et al., 2015).

However, as yet, most research that tested the effect of instrumental, environmental and symbolic attributes on adoption of sustainable innovations, and all studies testing the effect of the three attributes in concert, focused on proxies of adoption, such as acceptability of, interest in, and intention to purchase a sustainable innovation and did not study actual adoption. Yet, intentions may not always translate into behavior (Morwitz et al., 2007; Sheppard et al., 1988), and drivers of intentions to adopt innovations may not always correspond with drivers of their actual adoption (see Arts et al., 2011, for a review). Hence, an important question is to what extent people's evaluations of the different attributes also predict the *actual adoption* of sustainable innovations. Would the evaluations of symbolic attributes play an important role in predicting actual adoption as well, even when controlled for evaluations of the instrumental and environmental attributes?

1.3. Current study

We aim to address this gap in the literature in two ways. First, we will examine how evaluations of the three attributes of a sustainable innovation differs across those who adopted versus did not adopt a sustainable innovation. Second, we will study to what extent the evaluations of these attributes explain actual adoption of a sustainable innovation. As a case of point, we focus on adoption of smart energy systems by people who have solar panels installed on their roof. Such smart energy systems can monitor one's energy use and energy production of one's solar panels via smart meters and smart plugs. On the basis of this, the smart energy systems deliver households feedback on their energy use (total as well as on a plug level) and production via an app that can be installed on smart phones, laptops, tablets or computers. It is up to the user whether or not to actually change energy behavior. Such smart energy systems enable users to reach a better understanding of ways to reduce their fossil energy use and make better use of the solar energy they produce themselves. Users of the smart energy system can for instance learn how much energy is used by employing particular appliances, and thus how much energy can be saved by using them less. Also, users can learn to what extent their solar energy production matches their energy demand, enabling them to change their energy use behavior such as operating appliances at different times to better match their energy demand and supply, thereby optimizing the use of self-generated energy.

2. Method

2.1. Respondents and procedure

2.1.1. Description of the project that aimed to test smart energy systems

The study was part of a local project[1] that aimed to test smart energy systems, the sustainable innovation we focus on in this study. The project took place in a residential area, in and around the neighborhood Nieuwland in Amersfoort, a middle-sized city in the Netherlands. This neighborhood comprises single houses equipped with rooftop solar panels[2]; inhabitants were generally families with children. Early 2013, inhabitants were invited to join a local initiative called 'AmersVolt'. A campaign was launched to recruit project participants. The recruitment campaign included free publicity infomercials in local newspapers, and leaflets that were put in the mailbox of households in Nieuwland. The recruitment campaign was concluded with an informational event hosted at a local primary school. The event was announced in the local newspaper, and advertised on a mobile billboard in Nieuwland, two days prior to the event. After this event, residents could sign up as project participants and would receive a smart meter, five smart plugs and an app free of charge, in return for their participation in the project. The smart meter monitors their total gas and electricity use as well as the energy generated by their solar panels. The smart plugs aimed to monitor energy use of five large appliances. The app could be installed on their smart phone, tablet, laptop or computer and provides them with continuous one-hour resolution feedback on the basis of the metering devices installed. Notably, project participants received feedback on their total household energy use, total photovoltaics solar energy production, and energy use of five large appliances (e.g. white appliances, home entertainment systems) measured by individual smart plugs. Feedback was provided separately for electricity and gas usage. Project participants would receive feedback over a two-year long period, and had continuous access to their personal data.

Participating in the project meant a voluntary two-year long commitment as a research participant, using and evaluating a number of energy-related services deployed by the project, and giving project partners the right to collect one's household energy use data for research purposes. Project participants gave their informed consent for participating in the research aimed to evaluate the effect of the smart energy technologies on household energy use. Notably, they agreed to release their energy production and energy use data collected via the smart meters and devices. Furthermore, they committed themselves to fill out questionnaires on their motivation to participate, and their experiences with the system; the latter is not discussed here as it is not relevant for the purpose of the present paper.

2.1.2. Study sample

To study which factors affect the adoption of smart energy systems, we recruited a sample of people that decided to participate in the smart energy system project (i.e., adopters) as well as people who decided not to participate in the project (non-adopters). We recruited participants for the current study in two waves.

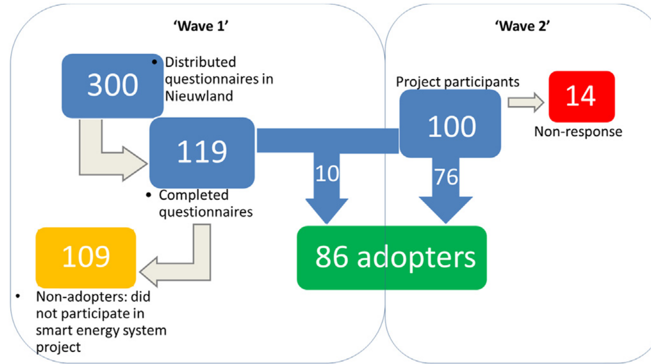

Fig. 2. Flow-chart of recruitment method, number of participants and non-response.

2.1.3. Wave 1

Before the start and announcement of the project and before the recruitment campaign, we approached inhabitants of Nieuwland at their homes (residents in the targeted neighborhood), and asked them to complete a questionnaire that aimed to study factors influencing the adoption of smart energy systems. Hence, at this moment, participants were not aware of the project. Smart energy systems were briefly introduced in the questionnaire as systems that provide users with feedback on one's energy use and energy production on the basis of smart metering data. It was indicated that the feedback aimed to facilitate users to optimally use their own produced solar energy, thereby reducing fossil energy use delivered by large energy companies. They could do so by reducing their energy use or by shifting energy use as to optimize demand-supply matching.

The questionnaire included, amongst others, questions about evaluations of the instrumental, environmental, and symbolic attributes of such smart energy systems. Late 2012, five research assistants distributed the questionnaires door-to-door among a representative sample of the project's target population. About 40% of the approximately 300 people contacted agreed to fill out the questionnaire. In total 119 questionnaires were recollected at participants' homes upon appointment (see Fig. 2).

As indicated above, early 2013, which was about three months after wave 1, the smart energy system project was officially introduced, and the marketing campaign to recruit project participants was launched (see above). From the sample of 119 respondents that filled out the questionnaire in the first wave, 10 decided to join the project.

2.1.4. Wave 2

As a result of the recruitment campaign, 100 households decided to participate in the smart energy system project. From these 100 households, 10 households had completed the questionnaire in the first wave (see above), while the other 90 households were asked to fill out the same questionnaire as used in wave 1 immediately after they decided to join the smart energy systems project (i.e., wave 2). Hence, data collection in wave 2 started immediately after people decided to join the project (i.e., early 2013), but well before the smart energy devices were installed; the actual installation of the smart energy system devices started in August 2013. Of the 90 project participants recruited in wave 2, 76 filled out the questionnaire (84% response), 14 did not and are not part of the current study.

[1] See www.smartgridrendement.nl for more information on the project (in Dutch).
[2] The solar panels were installed as part of the PV UP-Scale initiative in 1999.

Table 1
Socio demographics in the research sample compared to the Dutch population.

	Sample	Dutch population[a]
Gender (male)	65%	50%
Age		
19–25	3%	8%
26–35	11%	16%
36–45	35%	19%
46–55	32%	20%
56–65	9%	17%
65 and older	8%	20%
unknown	3%	
Education		
Primary or lower	1%	5%
Secondary and vocational	50%	60%
College and university	49%	34%

[a] Source: CBS, 2010.

2.1.5. Total sample

The description above reveals that in total 195 people filled out the questionnaire, of which 86 participated in the smart energy systems project; we will refer to this group as adopters. The remaining 109 respondents who filled out a questionnaire did not sign up for the project and were labeled as "non-adopters" of smart energy systems (see Fig. 2). The mean age of the respondents was 46 (SD=10.97); 127 respondents were male, 66 were female, while 2 respondents did not specify their gender. Compared to the Dutch population, participants in our sample have a somewhat higher level of education. Also, people between the age of 36 and 55 and males are somewhat overrepresented in our sample, while young adults and elderly people are somewhat underrepresented in our sample (see Table 1).

2.2. Measures

Respondents evaluated 6 instrumental attributes of smart energy systems, 3 attributes reflecting consequences of the use and ownership of smart energy systems for the environment, and 4 attributes reflecting outcomes of the use and ownership of smart energy systems for one's (self-)identity and status; see Table 2 and Appendix A for an overview of all items. Items were based on prior studies on the adoption of sustainable products (Noppers et al., 2014; 2015; Schuitema and De Groot, 2015; Sonnenberg et al., 2014). Respondents indicated to what extent they evaluated the instrumental, environmental, and symbolic outcomes positively or negatively, on a scale ranging from −5 to 5, with 0 meaning neither negative nor positive. When appropriate, responses were recoded so that a higher score on all questions indicated a more positive evaluation (see Table 2). Cronbach's alphas indicated that the items measuring instrumental attributes (α=.72), environmental attributes (α=.77), and symbolic attributes (α=.79) all formed reliable scales, so scores on the relevant attributes were averaged into three scales reflecting evaluations of instrumental, environmental and symbolic attributes of smart energy systems, respectively. A few respondents did not fill out all questions: three respondents did not fill out all items of the environmental attributes scale, while one of these three respondents also did not fill out all items of the instrumental attributes scale. These respondents were excluded from the relevant analysis.

3. Results

3.1. Evaluation of the attributes

On average, respondents evaluated the instrumental attributes (M=0.87, SD=1.23) and symbolic attributes (M=0.91, SD=1.38) of smart energy systems slightly positive, and evaluated the environmental attributes of smart energy systems most positively (M=2.55, SD=1.37).

3.2. Evaluation of the attributes by adopters versus non-adopters

To address our first question on whether evaluations of the three attributes of smart energy systems differ for adopters and non-adopters, independent samples *t*-tests were conducted to compare the evaluations of the three attributes of smart energy systems by adopters and non-adopters. Results showed that adopters and non-adopters only significantly differed in the evaluation of the symbolic attributes of smart energy systems: adopters were more positive (M=1.23, SD=1.26) about the symbolic attributes than non-adopters were (M=0.65, SD=1.43): $t(193)=-2.99$, p=.003. Adopters evaluated the instrumental attributes of smart energy systems on average slightly more positively (M=1.04, SD=1.15) than non-adopters (M=0.73, SD=1.28), but this difference was not statistically significant, $t(192)=-1.74$,

Table 2
Evaluations of instrumental, environmental, and symbolic attributes of smart energy systems.

	M (SD)
Instrumental attributes (Cronbach's α=.72)	**0.87 (1.23)**
Smart energy systems will cause: less power outages (−5) – more power outages (5)[R]	
Using smart energy systems will cost me: less time and effort (−5) – more time and effort (5)[R]	
Smart energy systems will: save me money (−5) – cost me money (5)[R]	
Smart energy systems will be: less capable in providing the energy I need (−5) – better capable in providing the energy I need (5)	
Using smart energy systems will make my daily life: less comfortable (−5) – more comfortable (5)	
Smart energy systems give me: less control over my energy use (−5) – more control over my energy use (5)	
Symbolic attributes (Cronbach's α=.79)	**0.91 (1.38)**
By using smart energy systems I will be: less able to distinguish myself from others (−5) – more able to distinguish myself from others (5)	
Smart energy systems fit with how I want to see myself: totally disagree (−5) – totally agree (5)	
I can show who I am by using smart energy systems: totally disagree (−5) – totally agree (5)	
The use of smart energy systems says something: negative about me (−5) – positive about me (5)	
Environmental attributes (Cronbach's α=.77)	**2.55 (1.37)**
By using smart energy systems CO_2 emissions will: decrease (−5) – increase (5)[R]	
By using smart energy systems environmental problems like global warming will: decrease (−5) – increase (5)[R]	
By using smart energy systems the quality of the environmental will: deteriorate (−5) – improve (5)	

[R] reverse coded in analyses.

Table 3
Logistic regression model explaining adoption of smart energy systems.

	Nagelkerke's R^2	X^2	df	-2log likelihood	p	OR[a]	LLCI[b]	ULCI[c]
Adoption of smart energy system	.09	13.08	3	251.003	.004			
Instrumental attributes						1.21	0.92	1.58
Environmental attributes						0.80	0.63	1.02
Symbolic attributes						1.41	1.11	1.79

[a] Odds-ratio.
[b] Lower Limit 95% confidence interval.
[c] Upper Limit 95% confidence interval.

$p=.084$. Average scores of the evaluations of the environmental attributes did not significantly differ for adopters ($M=2.48$, $SD=1.20$) and non-adopters either ($M=2.60$, $SD=1.50$): $t(190)=0.59$, $p=.559$.[3]

3.3. Testing the full model: explaining actual adoption with evaluations of the attributes

Next, to address our second question, we examined to what extent evaluations of the attributes explained actual adoption of a sustainable innovation via logistic regression analysis. Results showed that the three factors (attributes) as a set reliably distinguished between adopters and non-adopters (see Table 3). Adopters of smart energy systems had more positive evaluations of the symbolic attributes of smart energy systems than non-adopters had (see Table 3). Evaluations of the instrumental attributes and evaluations of the environmental attributes did not explain adoption of smart energy systems, as in both cases the odds-ratio did not significantly differ from 1 (see Table 3).

4. Discussion

First, we investigated differences in the evaluation of the instrumental, environmental and symbolic attributes of smart energy systems between adopters and non-adopters. Results revealed that respondents were on average somewhat positive about the instrumental and symbolic attributes of smart energy systems, while they evaluated the environmental attributes most favorably. Interestingly, adopters only evaluated the symbolic attributes of smart energy systems significantly more favorably than non-adopters, while their evaluations of the instrumental and environmental attributes did not differ significantly. This finding is in line with research comparing evaluations of attributes of sustainable innovations of groups that identify themselves as earlier versus later adopters. For example, research showed that people who see themselves as earlier adopters of innovative cars were more positive about the symbolic attributes of electric cars than people who see themselves as later adopters of innovative cars, but the extent to which someone sees himself or herself as an earlier or later adopter of innovative cars was not related to evaluations of the instrumental and environmental attributes of electrics cars (Noppers et al., 2015).

Second, we examined to what extent evaluations of instrumental, environmental, and symbolic attributes explained the actual adoption of smart energy systems. Our results showed that evaluations of symbolic attributes were the only significant factor explaining the *actual* adoption of smart energy systems, while evaluations of the instrumental and environmental attributes did not explain actual adoption when the evaluation of symbolic attributes were controlled for. This finding replicates results of studies examining factors influencing proxies of the adoption of different sustainable innovations such as interest in sustainable innovations, acceptability of sustainable innovations, or intentions to adopt sustainable innovations, which consistently found that evaluations of symbolic attributes are an important predictor of these indicators of adoption of sustainable innovations (Korcaj et al., 2015; Noppers et al., 2014; Noppers et al., 2015; Schuitema et al., 2013). This finding is also in line with qualitative data showing that self-expression is given as one of the reasons to adopt sustainable innovations (e.g., Heffner, 2007; Ozaki and Sevastyanova, 2011). Importantly, the current study shows that the evaluations of symbolic attributes can explain the actual adoption of sustainable innovations, even when the effects of other variables are controlled for. This is an indication of the robustness of the effect.

The finding that similar factors seem to predict different proxies of adoption and *actual* adoption of a sustainable innovation suggests that research on proxies of adoption can give relevant insights in which factors will influence actual adoption. Studying such proxies of adoption can be particularly useful in the very early stages of introduction of sustainable innovations, when only very few people have actually adopted the innovation.

Although evaluations of the attributes of smart energy systems significantly explained the adoption of these systems, a considerable proportion of the variance in adoption was not explained by the evaluations of its instrumental, environmental, and symbolic attributes. This suggests that other factors besides the evaluations of these attributes are also important for the adoption of smart energy systems. Future research could examine the role of other potential important factors promoting the adoption of sustainable innovations, like (environmental) values (Chen, 2014; Steg et al., 2015), social norms (Cialdini et al.,1991; Nolan et al., 2008; Ozaki and Sevastyanova, 2011; Schultz et al., 2007), knowledge and technical support (Jager, 2006), trust in the program or in providers of innovations, effort or resources needed to acquire the innovations, and marketing efforts (Stern, 1986; Stern et al., 1986). In addition, future research could consider individual differences in the extent to which different factors may predict actual adoption of sustainable innovations. A relevant individual difference factor may be adopter segment, that is, whether individuals are likely to be earlier or later adopters (Rogers, 2003; Noppers et al., 2015). Moreover, future research could investigate how and to what extent the symbolic attributes of sustainable innovations can be

[3] We explored differences in the evaluations of adopters who filled out the questionnaire before they decided to participate in the smart energy project (N=10), and adopters who filled out the questionnaire after they decided to participate in the project (without actually using the smart energy system yet; N=76). Levene's test for equality of variances revealed that variances differed significantly across both groups. A t-test assuming unequal variances revealed that on average, the two groups did not differ in their evaluations of the attributes. Hedges' g was used for calculating effect size because it accounts for different sample sizes (Durlak, 2009). Instrumental attributes: $M_{before}=1.50$, $SD_{before}=1{,}72$, $M_{after}=0.98$, $SD_{after}=1.06$; $t(84)=-0.93$, $p=.373$, $g=.045$). Environmental attributes: $M_{before}=2.87$, $SD_{before}=1{,}59$, $M_{after}=2.43$, $SD_{after}=1.14$; ($t(84)=-0.84$, $p=.419$, $g=.359$). Symbolic attributes: $M_{before}=1.65$, $SD_{before}=0.57$, $M_{after}=1.18$, $SD_{after}=1.31$; ($t(84)=-2.01$, $p=.055$, $g=.805$). Please note that these results should be interpreted with care, due to the small number of adopters who filled out the questionnaire before the smart energy system was introduced.

emphasized and enhanced, as to promote the adoption of such innovations.

4.1. Limitations

For firmly establishing a causal relationship between evaluations and adoption, ideally evaluations of the attributes are measured first and subsequently adoption behavior is measured. Unfortunately, we could not strictly follow this procedure. Yet, we did not find significant differences in the evaluations of the three attributes between adopters who filled out the questionnaire well before they decided to adopt and adopters who filled out the questionnaire right after they decided to adopt the smart energy system. However, these results should be interpreted with care, because only few respondents filled out the questionnaire before they decided to adopt smart energy systems (N=10). Moreover, people who filled out the questionnaire after deciding to participate in the project seemed to be somewhat more positive about the symbolic attributes of smart energy systems than people who filled out the questionnaire before the start of the project, yet the difference was small ($M_{before}=1.65$ vs $M_{after}=1.18$, Hedges' $g=0.805$) and not statistically significant.

Our sample included people who own solar panels and who live in a neighborhood including mainly family housing. Also, comparing the demographics of our sample to demographics of the Dutch population indicates that our sample is not fully representative of the Dutch population. Future research is needed to investigate whether our findings apply to the Dutch population as a whole, and to populations in other countries and cultures.

The smart energy systems were offered for free to participants of the project, provided that they granted permission to share their smart metering data with the research team, and provided that they would complete questionnaires aimed to evaluate their motivations to participate and experiences with the system. This could have influenced the adoption decision of our participants. Some people may have been interested in adopting the smart energy technology, but decided not to participate in the project because they were not willing to participate in the research project. On the other hand, some people may have participated in the project because the smart energy technology was offered free of charge, while they would not consider adopting it when they had to pay for it themselves. These are common problems faced when evaluating the effect of programs introducing sustainable innovations. Future research could investigate motives for actual adoption of sustainable innovations in a more realistic market setting to test the robustness of our findings. Furthermore, although smart energy systems were marketed in the area where we administered our questionnaires, we could not control for the level of exposure to marketing materials. Consequently, adopters and non-adopters could have had different level of exposures to these marketing materials, which could have contributed to the adoption decision.

5. Policy implications and conclusions

Our results have some implications for policy to promote smart energy systems, and more generally sustainable innovations. Our findings reveal the relative importance of positive evaluations of symbolic attributes in encouraging the adoption of smart energy systems. Policy could try to emphasize and strengthen the symbolic value of sustainable innovations. Governmental campaigns are an example of such a policy to stimulate adoption. Currently, such campaigns often focus on saving money or protecting the environment (e.g., Bolderdijk et al., 2013). Rather than merely stressing the instrumental and environmental benefits of sustainable innovations, or downplaying potential instrumental drawbacks, our research suggests that campaigns could also stress positive symbolic attributes of sustainable innovations. For example, it can be emphasized that adopting sustainable innovations signals positive traits like concern for others and intelligence (Heffner et al., 2007). Campaigns could demonstrate that sustainable innovations are typically adopted by innovative, environmentally friendly, or successful persons, thereby also communicating that adopting such innovations enhances one's social status (see also Noppers et al., 2015; Heffner et al., 2007). Similarly, campaigns could demonstrate that adopters of sustainable innovations are perceived by others as successful persons.

To conclude, what adopting smart energy systems says about a person is an important factor determining its adoption, as evaluations of the symbolic attributes explain *actual* adoption of smart energy systems, even when controlling for the evaluations of instrumental attributes and symbolic attributes. This is in line with earlier research predicting proxies of adoption of different sustainable innovations, which implies that studying proxies of adoption may yield important insights on which factors predict actual adoption. Studying proxies may particularly be relevant in the early introduction phase. Improving and highlighting the symbolic attributes of smart energy systems, and more generally sustainable innovations, can potentially be an effective (social) marketing strategy promoting adoption of sustainable innovations.

Acknowledgements

The authors would like to thank the Netherlands Organization for Scientific Research (NWO) and the project Smart Grid: benefits for all.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.enpol.2016.08.007.

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